Generators

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Introduction

This article is designed to give you an insight into generators that can be used with your caravan or motorhome.

This guide has been written in response to some of the questions that are asked on the **caravantalk.co.uk** forum

Before We Start!

SAFETY

Using any electrical equipment outdoors always carries a higher risk because of the increased chance of moisture, accidental damage etc. Please take extra care when using ANY electrical equipment outdoors.

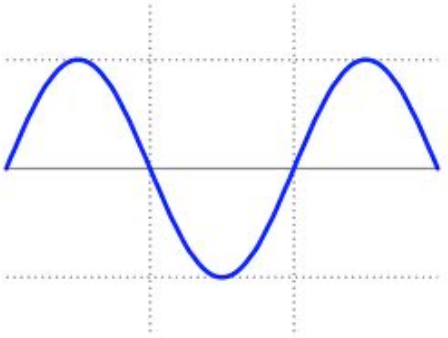
I have often seen postings on caravan and motorhome forums asking the question "What generators are OK to power my caravan?" There have always been a range of answers from "you can use any generator" to "you can only use your leisure battery"

Background

Modern electronic equipment is sensitive to the quality of the electrical supply it is connected to. With the development of switch mode power supplies and the components in them, many electrical devices now don't use a step down transformer and a bridge rectifier to produce the low voltage from the mains voltage that they need to operate. It is now possible to get a low voltage from the mains using just a hand full of components. Hence the rise in "power cubes".... the little black cube that plugs into the mains socket and has a lead that plugs into your device to charge or power it. If you look at the data plate for the device, you will often see that the operating voltage for the supply is 110 volts to 250 volts, 50 or 60 Hertz (Hz). That means you can plug it in anywhere in the world.

Manufacturers make the equipment with a wide operating voltage so the only have to produce one power supply for the whole world market. In the past the manufacturer of the equipment would have produced different equipment models for different countries. Typically it was broken up into The Americas, UK-Australia-NZ-Japan, Europe, Asia.

The normal way of powering these units is via mains (utility) supplied electricity, which is generally stable for voltage and frequency. In the UK, it is 240 volts RMS (more



about RMS later) at 50 hertz. On the continent, it is usually 220 volts at 50 hertz. As it comes out of the socket or EHU post it is a pure sine

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wave and the voltage and frequency (hertz) are controlled very precisely by the utility company.

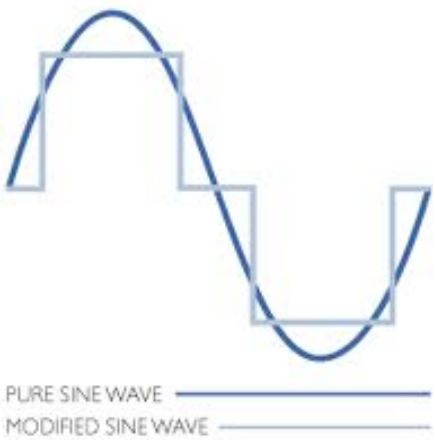
Now, to get this same electricity on a camp site for your caravan or motorhome, there are three ways of achieving it. The first is the simplest... just plug your caravan or motorhome into the EHU bollard. This will give you a supply exactly the same as it is at home and will only be limited in capacity by the circuit breaker supplying the bollard, usually (in the UK) 16 Amps or 10 Amps. On the continent, this may well be limited down to 6 Amps or even 3 Amps.

The second, is via an inverter run off your leisure battery.

Inverters

Inverters take one form of electricity and convert it in to another. The most usual type of inverters take 12 volts direct current - as supplied by a car battery or leisure battery and convert it to 220/240 volts alternating current (AC).

The output of inverters is not always the same as the electricity supplied by the utility companies. Cheap inverters will achieve the alternating current by simply switching the voltage/current from one direction into the opposite direction in steps by literally switching it electronically 50 times a second or "inverting" it. If you look at the shape of the waveform, rather than a nice smooth



curve, that we saw for the mains electrical supply, the shape is a step or a "modified" sine wave.

Most domestic electrical equipment (kettles, toasters etc) is quite happy running on this modified sine wave, unfortunately, a lot of electronic equipment, including microwaves and TV's is not. Plug in your laptop power supply, LCD TV, Satellite box to a cheap modified sine wave inverter and it will probably be the end of it.

Ok, there is a third way....

Petrol (gas) Generators

Generators work by having a small engine that can either run on petrol or gas (propane or butane) driving an alternator, which in turn generates electricity.

You have an alternator in your car usually driven by the fan belt. It generates electricity when your engine is running to power your accessories and charge your car battery.

Vehicle alternators are usually three phase (some high performance units for 4 x 4's are 6 phase) and have a set of diodes (electrical one way valves) to convert the three phase alternating current into the direct current to run your cars electrical system.

The standard petrol or gas generator still has an alternator, only this time, we use the AC output directly from the back of the alternator.

On cheap generators, the alternator is single phase and generates the 230 volts without any additional electrical components. The output from these is usually only suitable for running electrical drills, tungsten lights etc. and can be very "electrically" noisy.

On the more expensive petrol or gas generators, the alternator is three phase, still generating at 230 volts, but will have a simple electronic circuit to combine the three phases to produce a single phase output. These tend to be more efficient, and often will have a slightly higher output for a given engine size than the cheap single phase alternator equipped generators.

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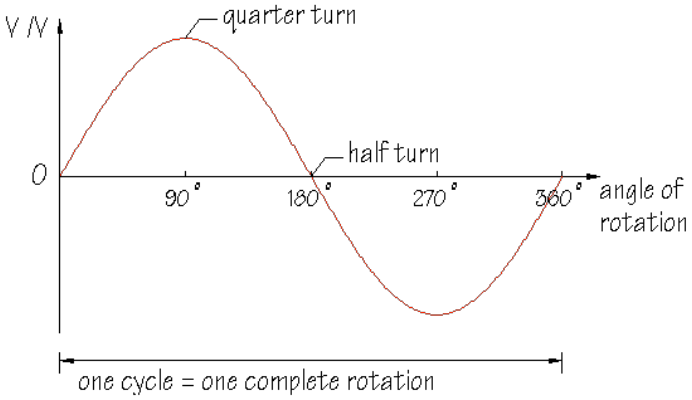
How an Alternator works

Have you ever wondered about the sine wave shape? Well that is created as the coils of the alternator spin past the magnetic lines of force. As the coil gets nearer to crossing the magnetic line of force pole, the amount of voltage generated increases, hence the start of the line of the sine wave increases, then as it cuts through the main magnetic pole at 90 degrees, the maximum voltage is generated and as it gets



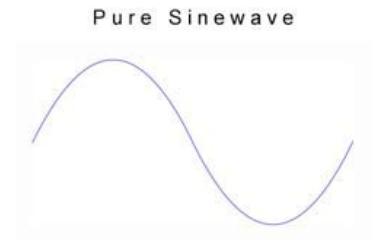
further away the amount of voltage generated decreases.... as the other side of the coil moves through the magnetic lines of force, the voltage is generated in the opposite direction in exactly the same way.... this gives the sine wave it's distinctive shape and is always nice and smooth.

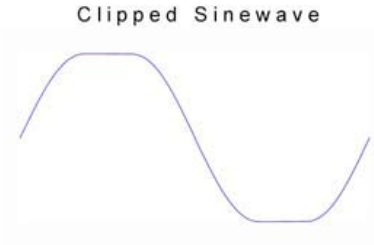
This happens 50 times a second and the frequency is linked to the speed (RPM) of the alternator, slow the speed down, the frequency will drop.

On a big generator that the utility companies run, the RPM of the alternator is closely monitored to give an exact frequency. On your small generator, this is not always the case. As you put more electrical load.. i.e. connect things to it, it takes more energy to move the wire coils of the alternator past the magnetic poles within the alternator. The small petrol engine is asked to do more work in keeping the alternator turning and it starts to slow down, therefore the frequency will reduce and the voltage will drop as the coils are now not passing the magnetic poles at the same speed. The generator will sense this (usually a small coil with a plunger inside connected to the carburettor) and via a mechanical linkage, open up the throttle on the engine, letting a bit more petrol through and increasing the speed of the engine.... got it yet? The frequency and voltage will fluctuate as the load changes on the generator. This is also compounded by the fact that small single cylinder petrol engines don't maintain a stable speed even with a stable load on them, they tend to "hunt" within a given RPM range.

So to sum up, a generator going on to full load will reduce frequency and reduce voltage. As it comes off load the frequency will increase along with the voltage. This is a problem, so how do the generator makers get round this?

Well, the frequency is not to much of a problem for 99% of equipment. The issue for the generator manufacturers is to stop the generator's voltage rising too much or dropping too much, so they get round it in a rater simple way. Instead of generating the correct voltage - 230 volts, they use alternators that generate about 300 volts and use an electronic circuit to "clip" the voltage. This clipping stops the voltage rising above a pre set limit - usually 230 volts and because the alternator is generating a higher voltage, if it does slow down due to additional load on it, then the voltage should still be above the clipped limit, therefore maintaining a relatively constant output.





If you look at the output of one of these generators you will see that the nice smooth sine-wave is now flattened top and bottom. This is known as a clipped sine wave and some electronic equipment is not happy with this as it was designed to accept a nice pure sine wave.

Microwave cookers are one piece of everyday equipment that don't like clipped sine waves, as they rely on the peak voltage to operate correctly.

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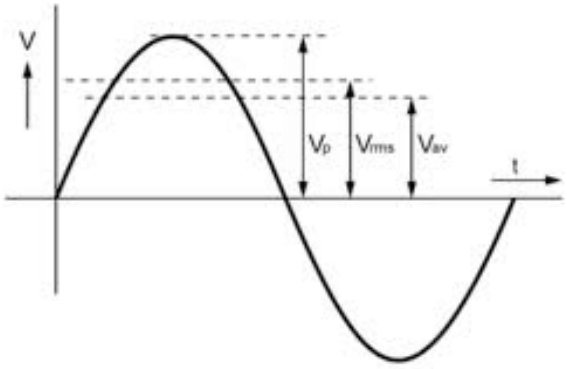
OK, to go further, we are going to have to get technical and delve into Peak and RMS voltages!

RMS and Peak Voltages

The Peak voltage (V_p) is the voltage measured exactly at the top (or bottom) of the sine wave. The RMS voltage (V_{rms}) is almost equivalent to the "average" voltage (V_{av}) of the sine wave... so



why do we need to know this?

In the days when transformers were used to reduce voltage, sometimes known as "step down" (or increase voltage - step up), the output was always quoted as the RMS Voltage - now without getting too bogged down in the maths , it is all to do with mathematically working out functions of a sine wave - square root and 1/ square root, but don't worry about it.

A near perfect sine wave is required for most electronic transformer-less power supplies. The reason is the internal circuits need to "measure" the true peak of the sine wave to adjust the output correctly by using a bit of maths.

Why do we use transformer less power supplies?

Transformer less units are lighter in weight, and usually cheaper to manufacture and are usually suitable for use world wide over a wide range of operating voltages and frequencies. Its because of this, that they need to be able to measure accurately the voltage that they are connected to in order to give the correct output voltage for the equipment they power. The only way to determine the correct voltage is accurately measure the peak voltage of the sine wave.

How do you work out Peak and RMS?

Without having to know how to work out square roots, there is a couple of simple calculations you can do and all you have to remember is two numbers. The first calculation works out the RMS voltage form the Peak Voltage.

The RMS (Route Mean Square) voltage is 0.707 times the peak. The peak voltage being the voltage at the peak of the sine wave.

To work out a Peak voltage form the RMS voltage simply times the RMS voltage by 1.414

So a generator that requires a RMS voltage of 240 volts actually generates a peak voltage of 338 volts (1.414 x 240 volts) and simply limiting this peak on no load condition affects the RMS. (It also alters the power factor depending on inductive or capacitive loads, but that is out of the scope of this guide)

It is worth noting, if you measure an AC voltage using a multimeter, the reading you will get is the RMS voltage, so you need to multiply this by 1.414 to get the peak voltage. As most manufacturers always quote "rated voltage" which is the RMS voltage, its not something you need to remember really.

So, now we know a bit more about generators and how they work and some of the issues about using them. How can they be improved?

Inverter Petrol Generators.

Some generator manufacturers realised that there was a market for small units that didn't have any of the associated problems, so they came up with the idea of a generator equipped with an alternator that could produce a three phase, high frequency high voltage output and feed this to a box of electronics similar to an inverter, where it is electronics that produce the nice smooth sine wave output at a stable regulated voltage. Electronics can react a whole lot faster than a petrol engine.

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One of the first companies to recognise that generators need to be improved was Honda. They saw a huge market in the USA where generators are used by householders that have lost their supply from the electricity company due to downed power lines. They produced some of the first generators that could be permanently installed and would run all types of equipment in the home from fridges to TV's.

Soon people were asking about smaller units to be able to take in their mobile homes and Honda produced a portable range of inverter units which in Europe is the EU10i, EU20i and EU30i range.

There are other manufacturers out there that

LPG Converted Honda EU10i

produce generators with the same or similar technology, but as I use Honda's, that is what I can tell you about.

How to work out the size of a generator

One of the most common problems with inverter generators is that of overloading. Nearly all the faults found on Honda's baby generator, the EU10i are due to them being overloaded. So how do we work out what we can plug in to a generator?

Generator output is usually given as kVA . "What?" I hear you ask....kVA is KiloVolt Amperes, and really not very useful when all we want to know is what we can plug in.

OK, some maths.... kVA is calculated like this...

(I x V)/1000 = kVA

(Current times voltage divided by 1000)

Thats still not helping really.... try this to get Amps....

(kVA x 1000)/V = A

(kVA times 1000 divided by Voltage)

Ahh... thats a bit better, so now we can start to work out what load we can plug in. So we have a generator with a 1.2 kVA rating, what can we plug in/

(1.2 x 1000) / 230 = 5.2 Amps

And to work out the power (watts)

230 x 5.2 = 1,196 Watts

So, you can see, if you plug your kettle from home into a 1.2 kVA generator.... you will overload it.

To make it easier here is a table of the common kVA ratings for generators and the calculated loads they can support:

kVA	Output @ 230 Volts Amps	Load at 230 Volts Watts
1.0	4.3	989
1.2	5.2	1196
1.4	6.0	1380
1.6	6.9	1587
1.8	7.8	1794
2.0	8.7	2001
2.2	9.5	2185
2.4	10.4	2392
2.6	11.3	2599
2.8	12.0	2760
3.0	13.0	2990
3.2	13.9	3197
3.4	14.7	3381
3.6	15.6	3588
3.8	16.5	3795

So you can see, its easy to overload a generator. If you wanted one to power everything in your

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caravan or motorhome exactly as you do using an EHU, you need to look for a generator that is rated at 3.8 kVA or above.

One unique feature of the Honda range is the ability to link two identical model generators together to double the output. (This is a feature that was introduced in the early emergency generators for the US market and has been maintained through out the range) As the inverter technology will sense the phase of the sine wave of it's partner unit, it will compensate it's phase and timing to match, so effectively "adding" its output to the other unit.

WARNING: DO NOT TRY TO CONNECT ANY OTHER GENERATORS TOGETHER OR ANY OTHER GENERATOR TO ONE OF THE HONDA UNITS!!!

They WILL go "BANG"

Honda produce a special lead for this, and only this lead must be used.

DO NOT EVER CONSIDER CONNECTING YOUR GENERATOR TO YOUR HOUSE ELECTRICS!

Earthing your generator

Something else you might want to think about is "earthing" or "grounding".

Most small generators are configured differently to the electrical mains supply in your house. Small generators have what is called a "floating" supply, that is to say that the earth is not connected to neutral. Now for using a single piece of equipment plugged into the generator, this is not a issue, but as we will be connecting a caravan, it is deemed that there will be more than one piece of "class 1" equipment connected, and therefore has to be treated differently.

It is important that the neutral is connected to the earth at the point of generation, therefore the neutral should have a link bonding it to the earth terminal on the generator.

This then will provide the return path for any fault current caused by contact between live parts and exposed conductive parts of the connected equipment. It will also ensure that any protective devices fitted to the caravan (ELCB's - RCD's etc) will operate correctly.

Now within the current regulations, there is not a requirement to bond neutral and earth on generators with a capacity of less than 10kVA, but it must be understood that your caravan RCD MAY NOT OPERATE CORRECTLY when operated on a generator.

Further information can be found here.... http://www.hse.gov.uk/foi/internalops/fod/oc/400-499/482_2.pdf

If you want to have your generator modified to connect Earth and Neutral most qualified electricians will be able to do this for you.

Additionally all small generators come with a grounding point on the generator frame or housing. This is for connecting the generator to a earthing spike.

Like anything technical, there is lots of information and safety advice to be gained by reading the manual that came with your generator.

Also, read your caravan or motorhome handbook about using generators. Some caravan or motorhome systems have a reversed polarity light fitted. When running a generator, it may illuminate showing reversed polarity. PLEASE REFER BACK TO THE CARAVAN OR MOTORHOME HANDBOOK FOR ADVICE.

I cannot accept any responsibility for anyone doing anything after reading this! Be warned!

Please, when using electricity outdoors...STAY SAFE!

PLEASE NOTE: This is not an advert or recommendation for Honda or its generators. There are other inverter generators available made by Kipor, Clarke, Yamaha and other companies. I have only sited Honda as I have extensive experience of them.

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